November 2011

AgroMetShell Overview

AgroMetShell (AMS) provides a toolbox for agrometeorological crop monitoring and forecasting. The current visual menu offers easy access to some of the most often used functions.

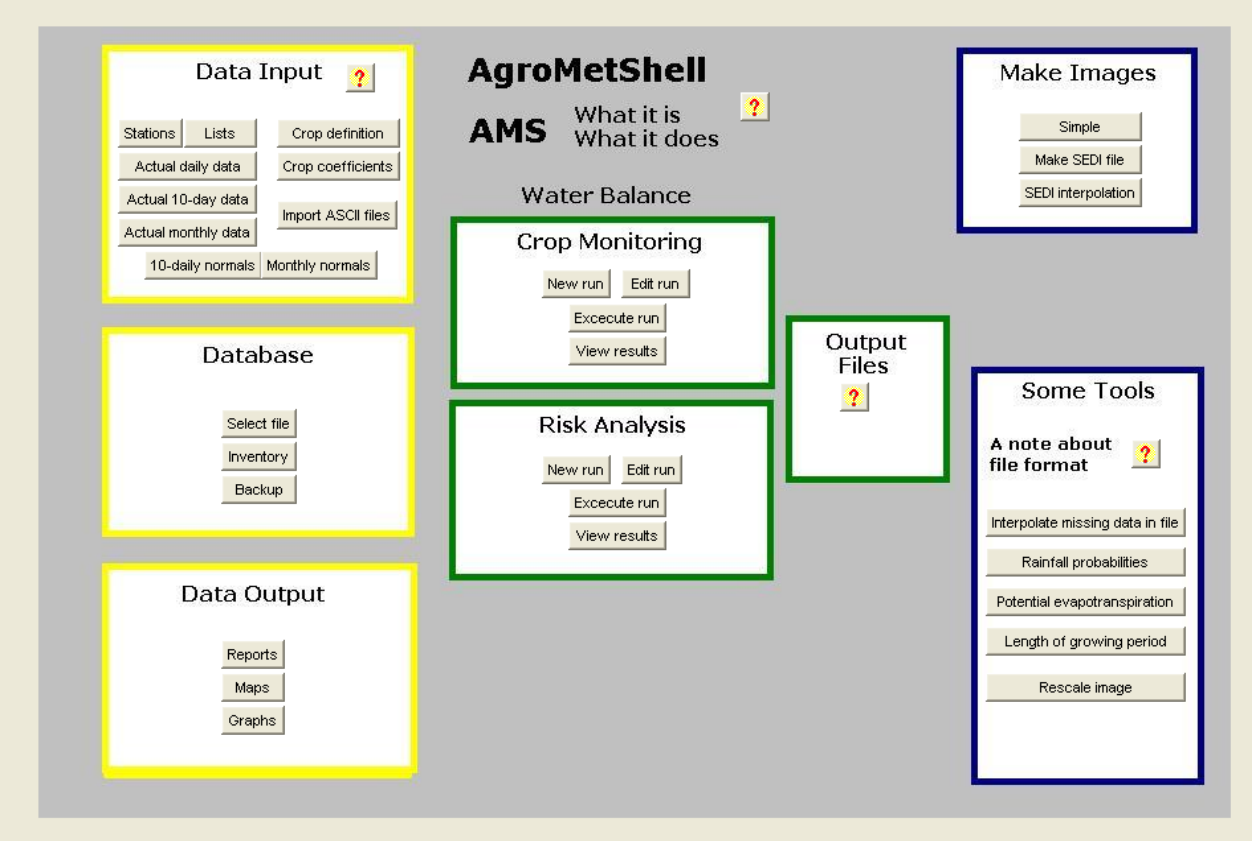
The program includes a database that holds all the weather, climate and crop data needed to analyse weather impact on crops. Data can be input into the database using a variety of options, for instance, they can be typed in from the keyboard, read from WINDISP format images or imported from ASCII files. Number of operations can be performed on the database, such as making backups or flushing the database.

The core of the program is the FAO Crop Specific Soil Water Balance. The basic of this soil water balance calculation is given in the file CSSWB.doc and in the watersatisfactionindex.xls

FAO Crop Specific Soil Water Balance can be operated in monitoring mode or in risk analysis mode. The first is an analysis for one growing season covering many stations in a specific area, usually a country or a province in a country. The second (risk analysis) covers the same type of analysis for one station only, but over many years.

The FAO Crop Specific Soil Water Balance produces a number of outputs: water balance variables, such as soil moisture, actual evapotranspiration over the vegetative phase or the water stress at flowering, etc. They can be mapped separately for crop monitoring. For crop forecasting, the water balance variables are normally averaged over administrative areas and then compared with crop yields through multiple regression to derive a Yield Function that in turn can be used to estimate yields.

In addition to the FAO Crop Specific Soil Water Balance, the program proposes many other useful tools, for instance the calculation of rainfall probabilities, spatial interpolation tools and the determination of growing season characteristics based on climatological parameters.



Data requirement

AMS input Files

To run any model or computer programme, data availability forms an important component of the whole process. The data requirement of AMS are quite reasonable when you compare it to other heavy duty models for crop simulation. There are basically 10 input files that one needs, to be able to run a water balance model in AgroMetShell as shown below. However, it may not be necessary to have all the input files listed depending on the circumstances. These circumstances may be that you are unable to calculate evapotranspiration on a dekadal basis and hence preparing an evaporation file may be difficult and one has no option but to use the normal evapotranspiration file. However, should the data be available, AMS has extra tools among which the tool to calculate evapotranspiration is one of them. There are also instances where the monitoring is done for rain-fed crops and therefore it may not be necessary to have a file on irrigation.

This basically reduces the number of files to run the water balance to 5 input files. Every time the user requests a water balance calculation to be carried out, the programme prepares a set of files that will be read by the Crop Specific Soil Water Balance programme to compute the water balance variables (such as soil moisture, actual evapotranspiration over the vegetative phase or the water stress at flowering, etc).

The files required are in comma-separated quoted string format and can be directly imported into a spreadsheet. All the files will have common data in the first four columns which will contain:

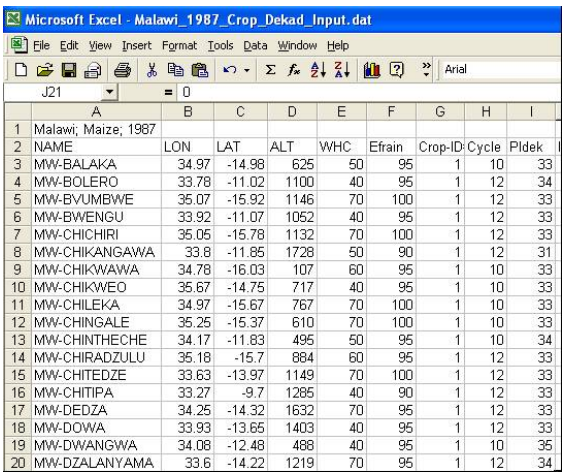
- "NAME", the station Name
- "LON", the longitude in decimal degrees
- "LAT", the latitude in decimal degrees
- "ALT", elevation above sea level

To run a crop specific water balance calculation, one needs the following files:

Input 1: Country Name_2003_Crop_Dekad_Input.dat

The file contains a summary of the parameters used to run the water balance, including the following:

- "WHC", soil water holding capacity
- "Efrain", effective rain (a percentage by which actual rain is multiplied to assess actual water supply. Usually Efrain<100% on slopes and Efrain>100% in low lying areas
- "Crop-ID#", the internal identification number of the crop
- "Cycle", the cycle length in dekads
- "Pldek", the planting dekad, a value between 1 and 36
- "Irrig", the type of irrigation (1=yes, 0=no and 2=automatic)
- "BundH", the height of the bund, for irrigated crops
- "k1","k2","k3","k4"…. Up to the value corresponding to the last dekad of the cycle, crop coefficients KCP



Microsoft Excel - Malawi_1987_Crop_Dekad_Input.dat

File Edit View Insert Format Tools Data Window Help

J21 = 0

	A	B	C	D	E	F	G	H	I
1	Malawi; Maize; 1987								
2	NAME	LON	LAT	ALT	WHC	Efrain	Crop-ID	Cycle	Pldek
3	MW-BALAKA	34.97	-14.98	625	50	95	1	10	33
4	MW-BOLERO	33.78	-11.02	1100	40	95	1	12	34
5	MW-BVUMBWE	35.07	-15.92	1146	70	100	1	12	33
6	MW-BWENGU	33.92	-11.07	1052	40	95	1	12	33
7	MW-CHICHIRI	35.05	-15.78	1132	70	100	1	12	33
8	MW-CHIKANGAWA	33.8	-11.85	1728	50	90	1	12	31
9	MW-CHIKWAWA	34.78	-16.03	107	60	95	1	10	33
10	MW-CHIKWEO	35.67	-14.75	717	40	95	1	10	33
11	MW-CHILEKA	34.97	-15.67	767	70	100	1	10	33
12	MW-CHINGALE	35.25	-15.37	610	70	100	1	10	33
13	MW-CHINTHECHE	34.17	-11.83	495	50	95	1	10	34
14	MW-CHIRADZULU	35.18	-15.7	884	60	95	1	12	33
15	MW-CHITEDZE	33.63	-13.97	1149	70	100	1	12	33
16	MW-CHITIPA	33.27	-9.7	1285	40	90	1	12	33
17	MW-DEDZA	34.25	-14.32	1632	70	95	1	12	33
18	MW-DOWA	33.93	-13.65	1403	40	95	1	12	33
19	MW-DWANGWA	34.08	-12.48	488	40	95	1	10	35
20	MW-DZALANYAMA	33.6	-14.22	1219	70	95	1	12	34

Input 2 and 3: Country Name_2003_Rain_Dekad_Input.dat
Country Name_2004_Rain_Dekad_Input.dat

The two files have actual rainfall for two consecutive years, as it often occurs that the crop is planted in one year and harvested in the following one. This kind of situation is what happens with winter crops in Belgium and with most crops in southern Africa where rainfall commences in September/October of one year and terminates in April/May of the following year. However, in situations where an agricultural season falls within a calendar year which is the case for spring wheat in Armenia, AMS will still work.

Input 4 and 5: Country Name_2003_Irrigation_Dekad_Input.dat
Country Name_2004_Irrigation_Dekad_Input.dat

The files contain actual values only if they have actually been provided. In monitoring rain-fed crops, these failes are not necessary.

Input 6 and 7: Country Name_2003_PET_Dekad_Input.dat
Country Name_2004_PET_Dekad_Input.dat

The two files have actual potential evapotranspiration for two consecutive years, as it often occurs that the crop is planted in one year and harvested in the following one. Evapotranspiration plays an important role in the water balance as it represents the atmospheric demand. If evapotranspiration is not available, it has to be calculated from other meteorological variables

Input 8 to 10: Country Name _Normal_Rain_Dekad_Input.dat
Country Name _Normal_PET_Dekad_Input.dat
Country Name _Normal_Irrigation_Dekad_Input.dat

The files contain normal rainfall, PET and Irrigation. The data from these files is utilized if the actual data is missing in the input files.

AMS Output Files

The programme generates 18 output files. It is not necessary that the user knows the details of the structure of those files, but with experience you may feel the need to carry out some non-standard analyses, in which case the information below will be of help. The names of output files are assigned automatically to the files based on the year, file list, type of data (input or output, daily or by dekad, actual or normal data) so that the file contents should be easy to determine. In addition, the first line of each file has a description of the data. Missing values in the files are usually coded as –999. All input and output files with DAT extensions follow the same "FAO format".

Two types of output files are produced. Those with extension TXT (text) provide some descriptive material about the crop monitoring exercise, while those with DAT extensions are in comma-separated quoted string data files used by other options of the programme, for instance many of the options under the *Tools* menu.

Output 1 and 2: TXT (text) output files, **Country Name _2004_Details_Dekad_Output.txt** and **Output_Comments.txt**

Output_Comments.txt simply lists information about the files as they are processed. An example follows:

AM-ARENI : No calculations done: Missing Planting Dekad
AM-MERDZAVAN : No calculations done: Missing Water Holding Capacity
AM-GYUMRI : Water balance calculated successfully
AM-YEREVAN : No calculations done: Missing Planting Dekad

The second file **(Country Name_2004_Details_Dekad_Output.txt)** contains the full details about the water balance. An example is given below. The abbreviations have the following meaning: **NOR** is normal rainfall, **ACT** is actual rainfall, **WRK** stands for "working" rainfall, i.e. **WRK=ACT*EfRain/100** if Act is available, otherwise **WRK=NOR*EfRain/100**, **Irr** is the irrigation amount if any, **PET** is the potential evapotranspiration while **WR** (the water requirement) is the product of **KCR*PET**. **AvW** is the crop available water, **S/D** stands for water Surplus or Deficit and, finally **INDEX** is the Water satisfaction index, the percentage of the crop water requirements that has actually been met. The end of the table lists actual evapotranspiration, water surplus and deficit by phenological phases:

Station number: 40/ Crop 14
Station Name: STATION000040 (Elevation:-999 m)
Crop type: Potato
Cycle length: 13 dekads (C)
Total water requirements: 389 mm (TWR)
Normal water requirements: 319 mm (TWRNor)
Planting dekad: 13 (P)
Maximum soil water storage: 100 mm (H or WHC)
Effective/Total rain: 100 % (E or EfR%)
Irrigation applied: Automatic
Bund Height: 50 mm (BUH)
Pre-season Kcr : 0.30

The actual rangeland index uses only actual data (NO estimates)

DATE	NOR	ACT	WRK	IRR	ET	KCR	WR	AVW	SW	S/D	INDEX
Jan-dek-3	24	1	1	0	2	0.30	1	0	0		
Feb-dek-1	6	8	8	0	5	0.30	2	7	7		
Feb-dek-2	48	42	42	0	2	0.30	1	41	48		
Feb-dek-3	21	31	31	0	2	0.30	1	30	79		
Mar-dek-1	9	24	24	0	6	0.30	2	22	101		
Mar-dek-2	72	34	34	0	5	0.30	2	33	133		
Mar-dek-3	30	66	66	0	6	0.30	2	64	150		
Apr-dek-1	97	18	18	0	22	0.30	7	11	150		
Apr-dek-2	80	46	46	0	7	0.30	2	44	150		
Apr-dek-3	57	31	31	0	16	0.30	5	26	150		
May-dek-1	191	56	56	0	25	0.50	13	43	150	43	100
May-dek-2	146	46	46	0	22	0.50	11	35	150	35	100
May-dek-3	119	45	45	0	21	0.50	11	34	150	34	100
Jun-dek-1	91	43	43	0	24	0.66	16	27	150	27	100
Jun-dek-2	120	24	24	0	29	0.93	27	-3	147	0	100
Jun-dek-3	165	16	16	0	30	1.15	35	-19	128	0	100
Jul-dek-1	152	2	2	0	41	1.15	47	-45	83	0	100
Jul-dek-2	22	0	0	0	42	1.15	48	-48	35	0	100
Jul-dek-3	29	6	6	0	31	1.15	36	-30	5	0	100
Aug-dek-1	41	2	2	47	47	1.15	54	-52	0	0	100
Aug-dek-2	10	1	1	41	43	0.98	42	-41	0	0	100
Aug-dek-3	71	4	4	24	34	0.82	28	-24	0	0	100
Sep-dek-1	104	9	9	13	34	0.65	22	-13	0	0	100

Phase	ETAt	Surplus	Deficit
Initial	35	112	0
Vegetative	43	27	0
Flowering	220	0	0
Ripening	92	0	0

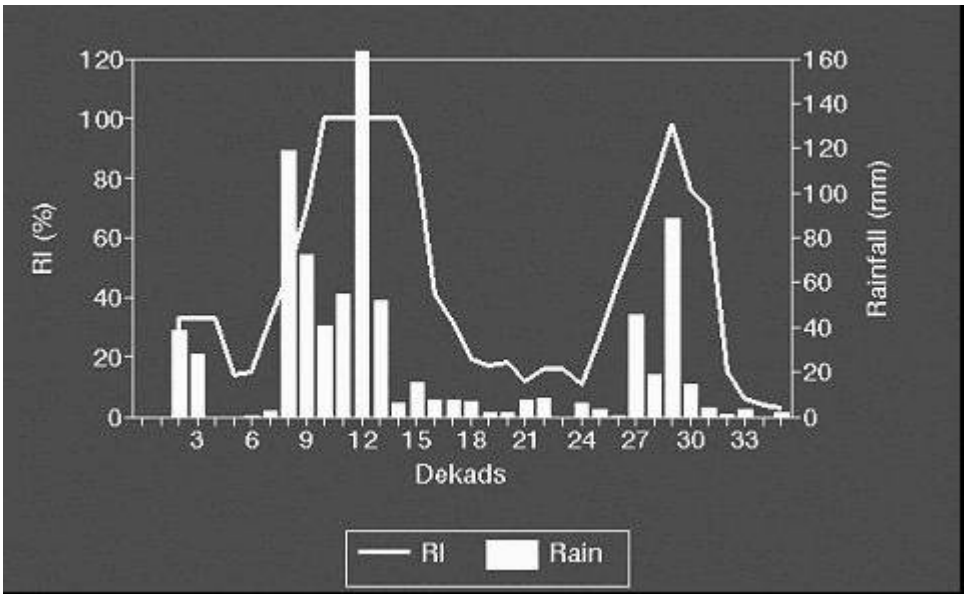
Surplus: 139mm (WEXt) Deficit: 0mm (WDEFt)
ETAt: 390mm % data avail:100% (%AVAIL)
Norm.index: 85% (INDXn)

Output 3 to 6: DAT output files,
Country Name _1998_WaterSatisfactionIndex_Dekad_Output.dat,
Country Name _1998_WaterStorage_Dekad_Output.dat,
Country Name _1998_WaterSurplusDeficit_Dekad_Output.dat and
Country Name _1998_ActualPET_Dekad_Output.dat

The files are "monitoring-oriented" as they contain sequences of several dekad values for display and inter-station comparisons. They respectively contain water satisfaction index values, soil moisture, water surplus or deficit and actual evapotranspiration, dekad by dekad, for all the stations in the list. Note that dekads are crop dekads (from 1 to cycle length). Values beyond cycle length are coded with the default value for missing data. D1, D2...D36 are the dekad numbers in crop dekads (i.e. planting dekad is 1 and the last values corresponds to C, the cycle length).

Output 7: **Country Name _1998_RangelandIndex_Dekad_Output.dat**

The "**rangeland-index**" (RI) is the classic FAO water satisfaction index computed for periods of 5 dekads, with normal evapotranspiration kept at potential level (KCR=1) and an assumed WHC of 50 mm. Similar to moving averages, the value assigned to a dekad corresponds to the five-dekad period centred about that dekad. Thus 3 for dekads 1 to 5, 4 for dekads 2 to 6... The rangeland index, when plotted over time, assumes a smoothed aspect, as shown in the figure below that compares "rangeland index" (RI) with rainfall (mm) in Msabaha (Kenya) in 1984**.** RI is associated with crop phenology. Based on local experience, there is usually a rather good association between planting and the RI. For instance, in Tanzania, it was found that the planting of millet usually occurs when the rising RI curve crosses the 0.4 (40%) threshold.



The RI is computed using actual rain (not "working rain" as described above, *i.e.* future values are coded as missing and not taken as their normal).

The dekads when the RI curve passes the 30 to 70% thresholds is given in the second text output file **(Country Name _1991_Details_Dekad_Output.txt** above).

Output 8: **Country Name _1991_Summary_Dekad_Output.dat**

The **"summary" output file** is certainly the most useful, as it lists the parameters which are likely to be used for further processing and analysis, in particular for developing yield models for yield estimation and crop forecasting. In addition to station ID, longitude (X) and latitude (Y), **%AVAIL** (percent of actual data used in the calculations) and Z (elevation) the variables listed in the "summary" are the following:

H and WHCi, the soil Water Holding Capacity, and its initial value, respectively;
EfR%, the ratio between effective and actual total and rain, in percent (Efrain, see above);
P, the planting dekad (1-36);
C, the length of the crop cycle (dekads);
TWR, total water requirements in mm;

Indx, IndxNor and IndxLatest, FAO soil water satisfaction index, in % of requirements, respectively **actual, normal** and **"last"** values. **"Actual"** corresponds to the value expected at the end of the cycle, **"normal"** is the end-of-cycle index computed with normal rain and PET, all other parameters being those from the crop file; the **"last"** value is that of the last dekad for which actual data are available ([1[1]]);

WEXi, WEXv, WEXf, WEXr, WEXt, water excess over the phenological phases described as initial, vegetative, flowering, harvest and the whole cycle (sum of previous values)

WDEFi, WDEFv, WDEFf, WDEFr, WDEFt, water deficit over the phenological phases and the value totalled over the growing cycle

ETAi, ETAv, ETAf, ETAr, ETAt, actual evapotranspiration over the phenological phases and the value totalled over the growing cycle

[1[1]] If there are no actual data available (in which case "actual" and "normal" are identical), then the "last" index is coded as missing.

ETA: actual crop evapotranspiration (i.e. actual crop water consumption), a factor directly related with crop yield;

%Av, ("available") the percentage of actual rainfall data used for the calculations (the rest being assumed to be "normal")

Cr1a to Cr4a and Cr1n to Cr4n (for "**Cr**ossing" and "**N**ormal **Cr**ossing") indicate the dates (dekads) when the rangeland index (see above) crosses the 0.4*PET line. The dekads given in the file can be used to map the beginning of the actual (current) season (Cr1 to Cr4) and the normal beginning (NCr1 to NCr4). In areas with only one rainfall peak, there is only one "normal" start, but there are two in bimodal rainfall areas. In marginal areas, where rainfall is very close to 40% of PET, there may be more than one "start" even in areas with uni-modal rainfall. The actual starts may be more than the "normal starts", particularly in the not so rare event of "false starts" when rain decreases again after a first start: in the field, farmers must frequently replant when this happens.

EXERCISE into AgrometShell (AMS)

AMS installation

The “Agrometshell.exe” installation file is given in the beginning of the training course.

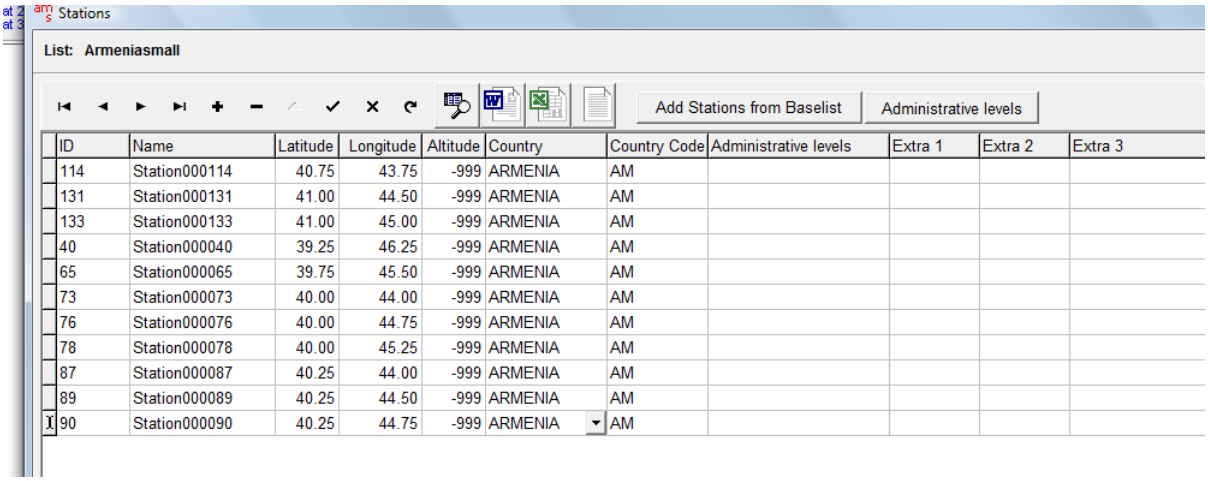
AMS configuration

AMS needs first to be configured in order to be adapted to your own work. This concerns the ascii editor, the boundary file (world.bna by default) that should be Armenia and the image file (world.img by default).

In the EDIT menu, go to “GENERAL CONFIGURATION” and modify the default values. Select a text (ASCII) editor in your computer, select the boundary file of Armenia and an image of Armenia. Finally in order to have this new configuration active, it is adviced to restart AMS. So, quit AMS and restart it.

STATIONS LIST

The command MANAGE STATIONLIST allows you to either create a list of stations that you will use to make a monitoring run or to load an existing list that you intend to use in running a water balance. To create a new list, select ***Create new list*** and then provide a name under ***Specify a new name for the list***. To load an existing list, click on the down arrow and select ***Load existing list*** and this will provide you with an option to select an appropriate list. Once the name of the list has been provided, you may ***click OK*** and the following screen appears allowing you to select the stations you want to be included in the list.



ID	Name	Latitude	Longitude	Altitude	Country	Country Code	Administrative levels	Extra 1	Extra 2	Extra 3
114	Station000114	40.75	43.75	-999	ARMENIA	AM				
131	Station000131	41.00	44.50	-999	ARMENIA	AM				
133	Station000133	41.00	45.00	-999	ARMENIA	AM				
40	Station000040	39.25	46.25	-999	ARMENIA	AM				
65	Station000065	39.75	45.50	-999	ARMENIA	AM				
73	Station000073	40.00	44.00	-999	ARMENIA	AM				
76	Station000076	40.00	44.75	-999	ARMENIA	AM				
78	Station000078	40.00	45.25	-999	ARMENIA	AM				
87	Station000087	40.25	44.00	-999	ARMENIA	AM				
89	Station000089	40.25	44.50	-999	ARMENIA	AM				
90	Station000090	40.25	44.75	-999	ARMENIA	AM				

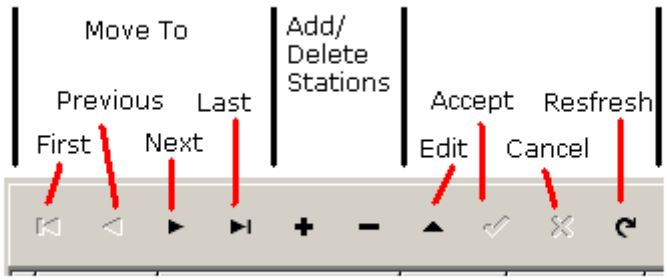
In this exercise, create a new list of stations and call it “Armenia”.

Stations can either be taken from the <Base List> if already included or entered directly into this window. For all stations the following attributes can be defined:

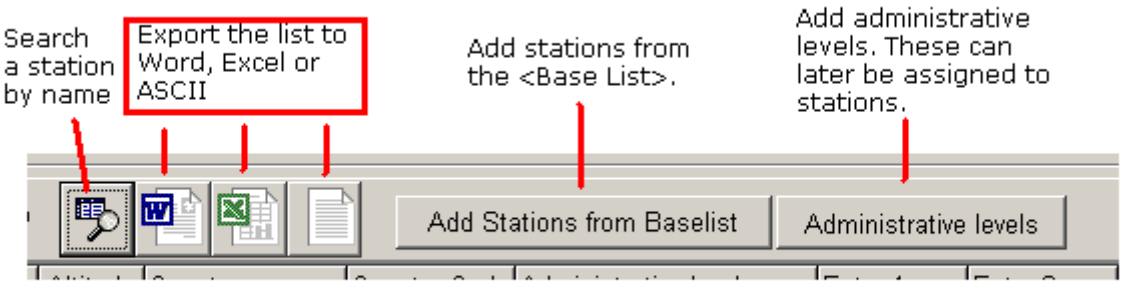
- ID. This is a code that uniquely identifies the station in the database
- Name. This is the name of the station.
- Latitude and Longitude : the coordinates of the station.
- Altitude. The elevation of the station (height above sea-level).
- Country and Country Code. The name of the country in which the station is located.

- Administrative levels. The administrative level 1 and 2 within a country. E.G. Province and District.
- Three extra attributes (to be filled at will).

The buttons at the top have the following functions:



Then, a number of buttons provide other ways to manipulate the list:


Search a station by name
Export the list to Word, Excel or ASCII
Add stations from the <Base List>.
Add administrative levels. These can later be assigned to stations.
Add Stations from Baselist
Administrative levels

Pressing <OK> will save the list. Pressing <Cancel> will cancel all changes.

In this exercise, you are asked to enter directly 5 Armenian weather stations !

DATA INPUT

This exercise will serve for the preparation of input data for the water balance calculation that will be done later.
The FAO methodology for the water balance calculation is based on two main assumptions :

1. the ten-daily time step is sufficient to estimate with an acceptable accuracy the water balance for agrometeorological purposes;
2. Normal potential evapotranspiration (PET) can be used instead of actual reference evapotranspiration (see notes of Frere and Popov (1979) for more explanations) when actual PET is not available.

The water balance will calculate the evolution of the soil water content according to rainfall input and deep percolation and actual evapotranspiration output. This calculation is run at a 10-daily time step. Percolation may also be calculated but this has no operational meaning for an agrometeorologist and will be skipped here. Therefore we will need dekadal values of both ET0 and rainfall data.

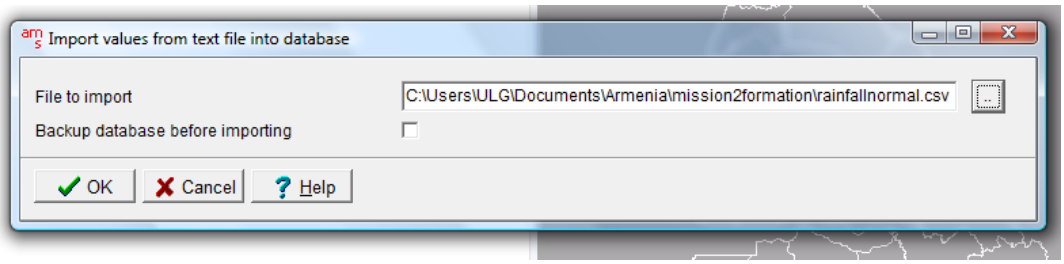
1. Introduction of Normal data

The exercise is done with data from Armenia. Normal monthly data of 9 rainfall stations and normal monthly values of Mean Temp of 8 stations are available into the FAOCLIM database. A rapid presentation of this database will be done by B. Tychon.
All the data available were saved in 2 files named rainfallnormal.dat and Meantempnorm.dat. Open these files and confirm that the data do correspond with reality.

Then, with Excel spreadsheet, modify the format of the 3 files in order to have
Column A : station name
Column B : station ID
Column C : Longitude
Column D : Latitude
Column E : Altitude
Next columns : Monthly values from January to December.
Delete all the other columns.
Save these files in CSV format (comma separator) with the following names:

- rainnorm.csv
- meantemp.csv.

Once you have saved these data, go into AMS and try to import these Temp and Rainfall normal data into AMS using the 'import' button (or the menu Database/import/from ascii file) and replying to the different steps requested by AMS.



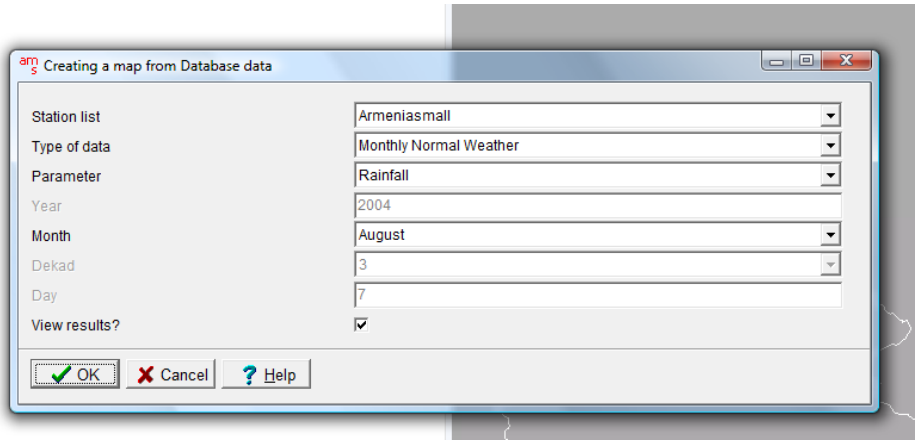
Be careful ! Verify that the station names are exactly the same as those you already introduced into the database before importing them ! Any spell mistakes will lead to the building of a new 'wrong' station and you will have to restart the import procedure.

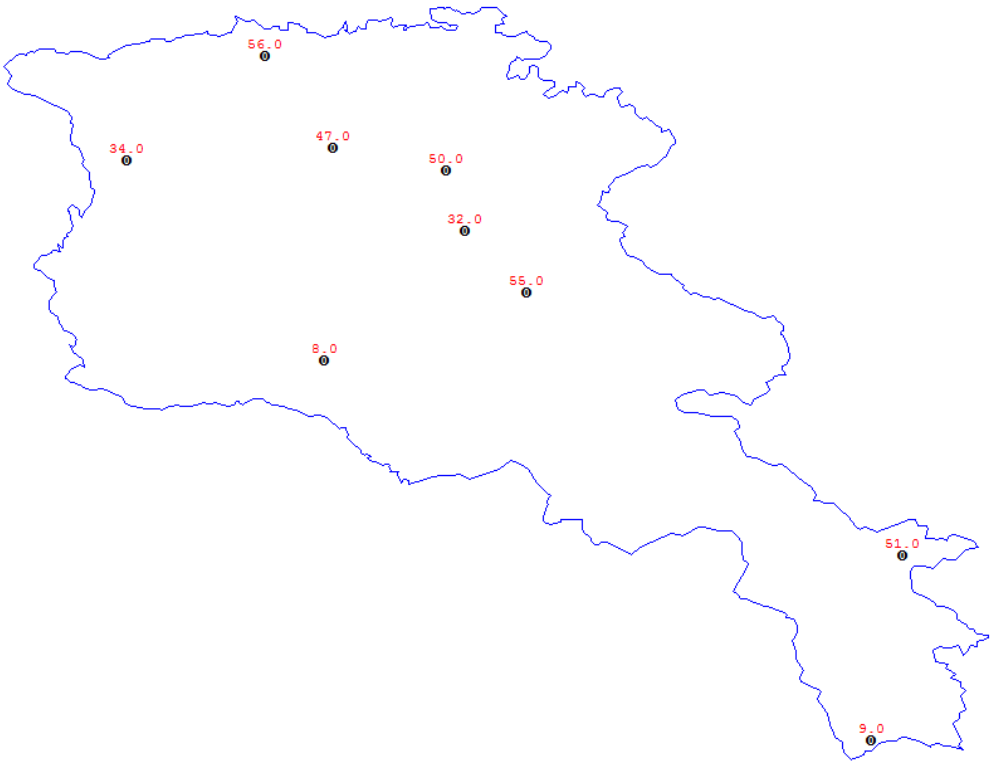
The importation procedure will be presented during the course on some examples by B. Tychon

If the importation runs well, you should see the results in the menu DATABASE/DATA INVENTORY. Please check it.

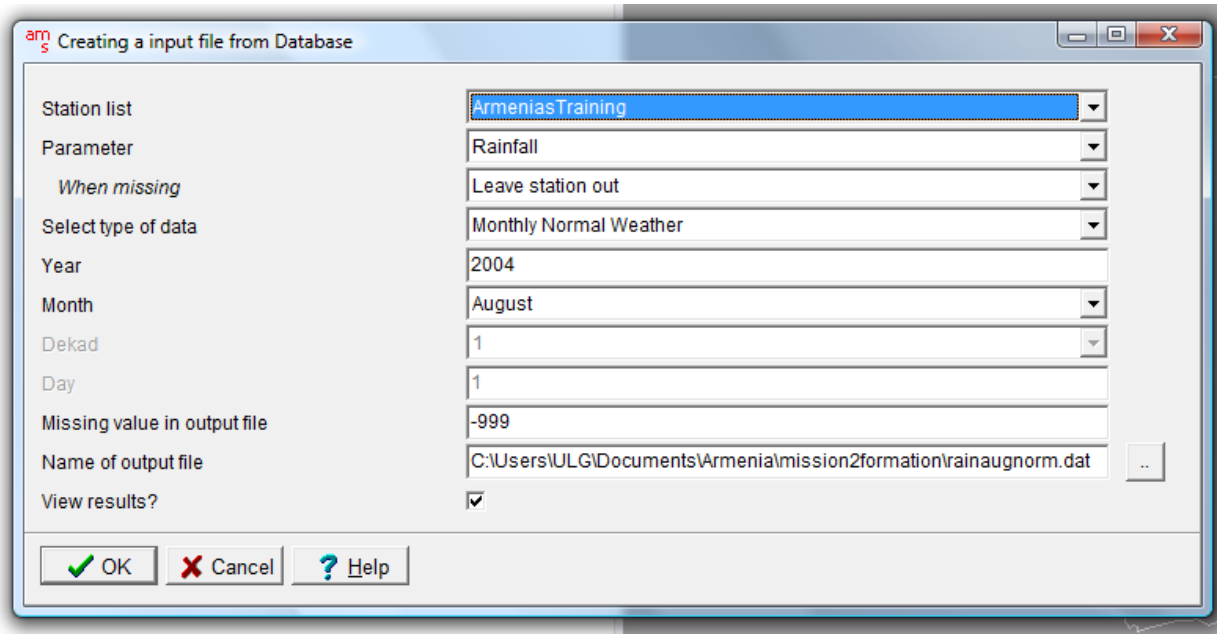
You can see the results of the new data on a map in the menu DATABASE/MAP. Try for example to see the rainfall values on the map for the month of August. Choose also another month with dryer conditions.

There exists two ways to do maps. The first one will show stations values on a map. You can have this presentation by applying the following procedure : DATABASE/MAP. The example here is for normal rainfall in August.

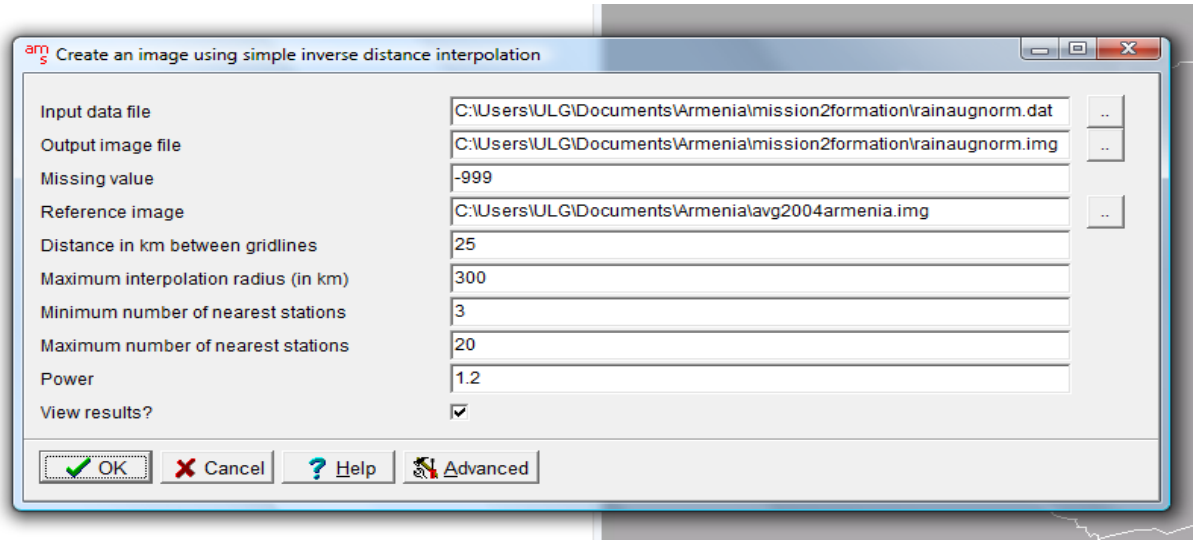




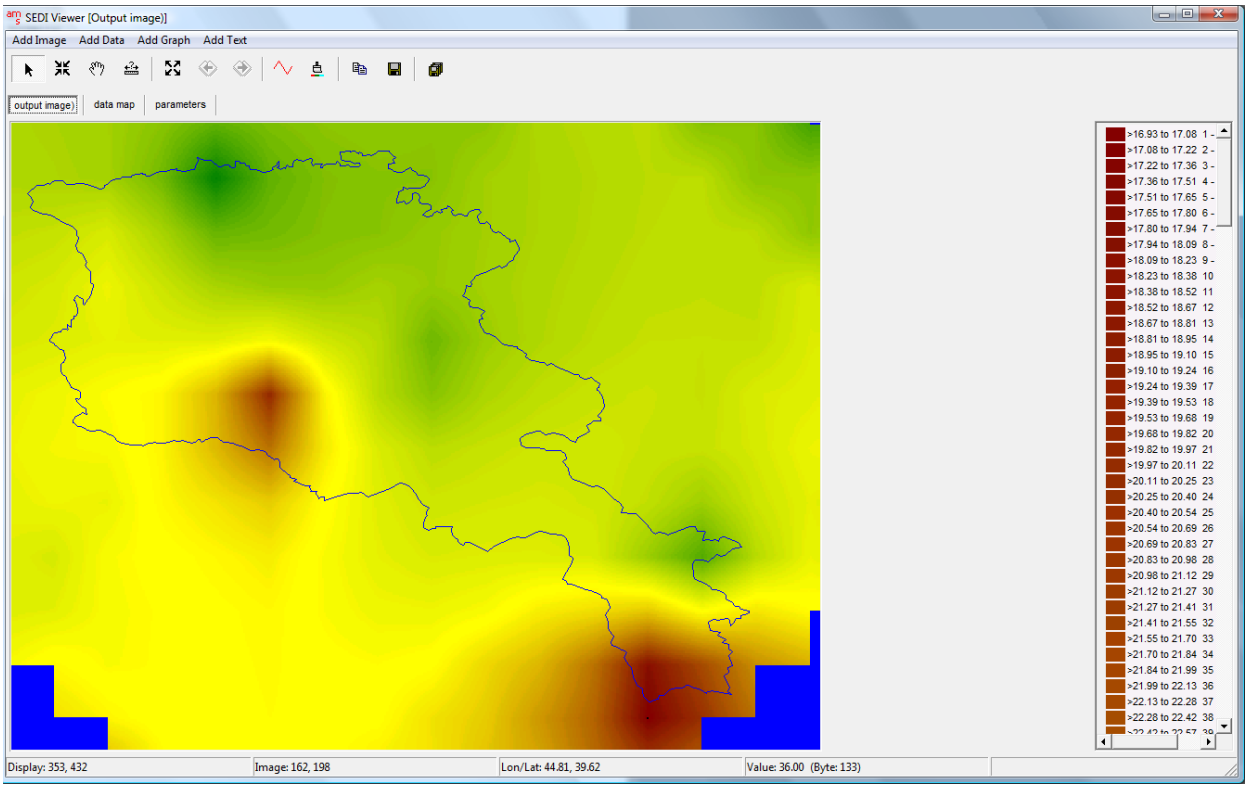
The second one will request an interpolation procedure before mapping. First open the menu INTERPOLATE/MAKE INPUT FILE/DATABASE to create an output file that will serve in the interpolation.



Next, do the interpolation with the following command : INTERPOLATE/INVERSE DISTANCE



You should have such map.



These maps can be saved to be used in report or bulletin you may have to write. They have the windisp format and can therefore be improved for report presentations.

You can also see your rainfall values using the report button into the DATABASE menu.
In the first line you must say in which list you want to get the data (Row): ARMENIA.
In the second line must be defined the Type of data : for example Normal Monthly values.
The third line is for the Parameter name (Rainfall, Wind speed,…). Choose Rainfall.
Then you must write which period you want to be put into the report (for example month 8 to month 11).
Once this is done, you can add this information in the report using the “add column” button. You can do it several times, choosing different column ‘types of data’ and ‘parameters’. When you have the wished number of columns, you can send this to a Worksheet (excel) or a Wordprocessor (word) or more simply into an ascii file Editor.

These monthly Normal data need now to be converted into 10-daily data using the conversion process into the DATABASE MENU /CALCULATE/NORMALS/DEKADAL FROM MONTHLY PROCEDURE. Please verify the results into the Data inventory in the Database menu.

2. Introduction of actual data

You can then introduce actual rainfall, relative humidity, wind speed, sunshine duration, amx and min temperature from 1998 to 2010 for all available stations. The station choice will be done during the exercise.
These data will be provided by you. They can be daily or dekadal data. These data should be converted into an ascii files (csv format) and then imported into the AMS database. Please check that the importation runs well by looking at the Data Inventory. You can also see these actual data on graphs by selecting the ‘Graph’ option into the Database menu. Try to see 3 stations together on your screen !

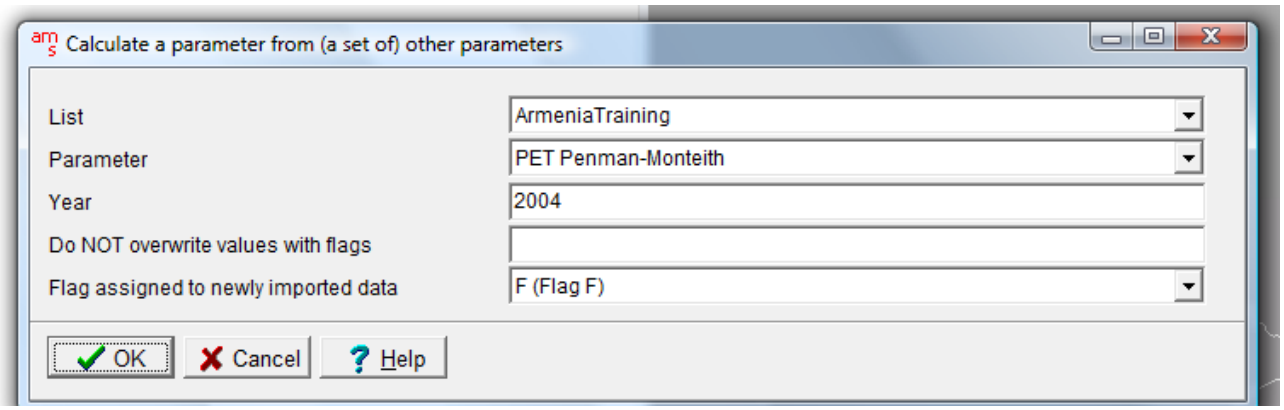
3. ET0 or PET calculation

This second exercise will concern introduction of actual daily weather data with the calculation of the reference evapotranspiration.

We will use data introduced in the previous step into the database. PET or ET0 can only be calculated if the following meteorological variables are available :

- Minimum Temperature
- Maximum Temperature
- Average relative humidity or max and min relative humidity
- Average wind speed
- Sunshine duration or Global radiation

If all this data is available in the database, which is the case in this training session, you can proceed to the PET calculation.
Calculate the ET0 using the formula available in AMS (DATABASE/CALCULATE/FORMULA)



ET0 will be calculated automatically and saved in the AMS database. Check the results in the data inventory. (DATABASE/DATA INVENTORY).

If the data are daily data, you can convert them into dekadal values using the option CALCULATE/AGREGATE into the DATABASE menu. This option will tranform automatically your daily values into dekadal and monthly data. Apply this process for all stations into the ArmeniaTraining list to convert daily data into dekadal date and dekadal data into monthly data.

If one of the meteo input data for the ET0 calculation is missing, it has to be estimated. For example, solar radiation, R_s, can be estimated with the Hargreaves formula :

$$R_s = k_{Rs}\sqrt{(T_{max} - T_{min})}R_a$$

where

R_a extraterrestrial radiation [MJ m^{-2} d^{-1}],
T_{max} maximum air temperature [°C],
T_{min} minimum air temperature [°C],
k_{Rs} adjustment coefficient (0.16.. 0.19) [$°C^{-0.5}$].

The square root of the temperature difference is closely related to the existing daily solar radiation in a given location. The adjustment coefficient k_{Rs} is empirical and differs for 'interior' or 'coastal' regions:

- for 'interior' locations, where land mass dominates and air masses are not strongly influenced by a large water body, $k_{Rs} \cong 0.16$;

- for 'coastal' locations, situated on or adjacent to the coast of a large land mass and where air masses are influenced by a nearby water body, $k_{Rs} \cong 0.19$.

In our exercise, one stations, Areni has no sunshine measurement and these measurements only start in 2004 for Merdzavan. Use the file “extraterrestrialradiation.xls” to calculate the Hargreaves formula for year 2007. Then import these new solar radiation data into AMS.

When wind speed is missing it can be replaced by values observed in the closest stations or in the worse case by a constant value of 2 m/s.

Missing relative humdity may also be estimated if data are lacking or are of questionable quality, an estimate of actual vapour pressure, e_a, can be obtained by assuming that dewpoint temperature (T_{dew}) is near the daily minimum temperature (T_{min}). This statement implicitly assumes that at sunrise, when the air temperature is close to T_{min}, that the air is nearly saturated with water vapour and the relative humidity is nearly 100%. If T_{min} is used to represent T_{dew} then:

$$e_a = e^\circ(T_{min}) = 0.611 \exp\left[\frac{17.27 T_{min}}{T_{min} + 237.3}\right]$$

The relationship $T_{dew} \approx T_{min}$ holds for locations where the cover crop of the station is well watered. However, particularly for arid regions, the air might not be saturated when its temperature is at its minimum. Hence, T_{min} might be greater than T_{dew} and a further calibration may be required to estimate dewpoint temperatures. In these situations, "T_{min}" in the above equation may be better approximated by subtracting 2-3 °C from T_{min}.

You can calculate missing relative humidity with the actualvaporpressure.xls file. You just need to replace Tmax and Tmin with the values of your stations.

The reference evapotranspiration (ET0) can also be calculated with AMS by using in the menu TOOLS/POTENTIAL ET. You have there two options to calculate it, either manually, by introducing all the weather parameters day by day or by using a FAO format file that contains all the necessary input variables. A example of such file is ET0solutionmultan.csv. Try this option with that file ! Be careful! Never use at the same time an average input variable with max and min values of that same variable.

AMS can also serve for the encoding procedures. These procedures may be activated by clicking on the different buttons on the ‘visual menu’ or more classically through the Database menu choosing the option ‘manage weather data’.

AMS may be used as a basic tool for the management of weather data. It will be you who will decide in your Service if this is worthwile to introduce or import the weather data into this new Database Management System. Please note finally that not only weather data can be introduced into the Management System but any kind of data including agricultural statistics, food prices, fertilizer amounts applied, etc.

WATER BALANCE

We are now moving to the core of AMS which is the calculation of the soil water balance. This is located in the middle part of the visual menu.

Before starting the water balance calculation, lets have a look at the crop coefficient. You can use default values for defining crop coefficient and length of each crop stage or you may define your own set of parameters for the crop on which you want to simulate the water balance. Create your own wheat crop coefficient based on what is given in the “crop evapotranspiration” manual. Save this new set as ‘armenian’. Please note that the initial stage is subdivised into several periods to take account on winter crops passing winter and a part of spring in this initial stage.

You can start by clicking on the 'New run' button. Enter the name you want to give to this run. Choose the list with the stations where you want the water balance to be done. Select the starting year for the run and give the name of the crop you want to simulate. For this exercise we will call this run "Armenia-wheat_2009". We'll work with the 3 stations of the 3 provinces with 2008 as starting year and we'll do the simulation for wheat.

After validation, a table to fill will be presented. You will have to choose for each station in the selected list,

- the dekad of sowing,
- the cycle length,
- the water holding capacity,
- the percentage of rainfall that will be effective for the soil-plant system,
- the pre-season coefficient that represents the amount of water lost by bare soil and weeds before the sowing date when compared to the reference evapotranspiration,
- the irrigation application : 3 possible options : no irrigation (rainfed crops), irrigation applications calculated by AMS for keeping the Water Satisfaction Index to 100% during all the crop cycle or irrigation applications according to information provided as input data for the different stations. In this last case, input data should be incoded into the AMS database using the 'actual 10-day data' button and choosing the parameter 'irrigation'.
- The bund height of the plot when irrigation consists on plot water ponding.

This table can be filled record by record. In this particular exercise, we will use the button that will set the same value for all the column. Values for the different parameters of this table will be choosen during the course. Note that in all the table, a cell, a line or a column may be selected as the default one if you activate one of the 4 'set default' buttons above the table. Check it.

You may then either just save this set of parameters or save and run the water balance. Select this last option and run the water balance model. This run a water balance for all stations with actual dekadal rainfall and actual dekadal potential evapotranspiration. This means that you must absolutely have these two informations if you want AMS to calculate the water balance. When data are missing, they are replaced by normal data. Check it by doing the same simulation but this time for the campaign 2003. This will allow to simulate what happens when actual data are missing (we have no ET0 data in 2003 for Merdzavan). What happens with the output ? Are there problems with some stations ? Can you explain why ?

All the output files of the waterbalance calculation are available in the output directory you selected in the running process. Go to this directory and open all the output files et check that you understand their content.

In a first step, run the water balance calculation with no irrigation application (Option 0). During the run, all the results are saved in different files. The definition of each output variable is given in the AMS user manual. Take ten minutes to read it carrefuly.
You clearly see that the Water Satisfaction Index in Armenia when starting crop in the first dekad of May fall to very bad values in some districts. This simply means that, in these areas, acceptable yields may only be obtained with irrigation or in soil with very high water holding capacity. The second option (Option 2) for the irrigation application may then be applied. AMS will calculate the amount of water to apply on the field to keep the WSI to 100%. Compare the amount of ETA of the two different simulations. Do it for the 3 stations.

Finally, use your own data of irrigation schedule according to your personal experience or the one from your colleagues (Option 1) and apply it to the 3 stations.

Make an image of the water balance results using WATER BALANCE\MAKE IMAGE FROM RESULTS. This option of AMS allows you to draw maps of all the outputs of the summary output file, the most important output file that gives the essential information. In the present case, draw a map of the ETA(total), WSI (Last index) and Water deficit at flowering stage.

Once you have calculated the waterbalance for 2004, do it for the different years you have in your database, especially for the period where agricultural statistics are available.

RISK ANALYSIS RUN

This option is quite similar to the water balance but this time, instead of runing the water balance for a particular year on a set of weather stations, we will calculate the water balance for several years on a unique selected weather station. The objective is the analyse of the evolution of the water stress on a great number of years in order to specify for each station the risk to have a water stress problem. Based on this risk evaluation, the farmer will decide on the strategy to fight against the stress (crop variety, crop practices, type of sowing (dry or wet), irrigation,…).

We can do the exercise on the Areni station in Aremia where data from one station are available for 12 years (1998-2010). Run it using the new run 'button into the risk analysis window or through the menu 'WATER BALANCE/RISK ANALYSIS RUN/NEW.

Analyse the results. What are the risks to have high water stress around this station ? What is the average amount of irrigation water necessary in 2004 to keep the crop in optimal growth conditions?